EXPLANATION OF PLATE XI.

Fig. 1. *Acantholeberis curvirostris* (Müller), ♀.
Fig. 2. Anterior antenna of the same species.
Fig. 3. Portion of the terminal half of the seta attached to the first joint of the lower branch of the posterior antennæ; greatly magnified.
Fig. 4. Portion of the terminal half of the seta attached to the second joint of the lower branch of the posterior antennæ, greatly enlarged.
Fig. 5. Abdominal claws.
Fig. 6. *Acantholeberis sordida* (Lievin), ♀.
Fig. 7. Abdomen of the same species.
Fig. 8. Setæ from the ventral margin of the carapace.
Fig. 9. Setæ from the posteroventral angle of the carapace.

XLV.—*On the Form of the Cells made by various Wasps and by the Honey Bee; with an Appendix on the Origin of Species.*

By the Rev. Samuel Haughton*, Fellow of Trinity College, Dublin.

The geometrical form affected by the cells of various kinds of wasps and bees has attracted the attention, and called forth the speculations, of naturalists and geometers from the earliest periods. By one class of writers the geometrical properties of these cells have been used as proofs, not so much of the skill and instinct of the insects as of the wisdom and intelligence of their Creator; while, by the opposite class of writers, these same geometrical properties of the cells are alleged as a sufficient cause for the production of the insects that make them, from the advantages which these forms of cells are supposed to possess over other forms—advantages said to be so important as to decide the battle of life in favour of the insects that adopt the geometrical plan of making their cells.

I have for a long time felt convinced that both parties in this controversy are in error, as men generally are when they attempt to speculate on the reasons for the existence of things; and that the properties of the cells are only the necessary consequence of their geometrical form, which form itself is the necessary consequence of mechanical conditions totally unconnected with design, and incapable of rendering an account of the origin of the insects that make the cells.

The geometrical cell of the wasps and bees that I have had an opportunity of examining may be divided into three classes.

1st. Hexagonal cells formed of adjoining pyramidal figures, with slightly curved axes, not terminating in a point, but in a rounded extremity.

* Read before the Natural History Society of Dublin, November 21, 1862. [Reprinted from a separate pamphlet by permission of the author.]

The British tree-wasp forms its pupa-cells in this manner, and, in consequence of the pyramidal form of the hexagonal cells, the comb opens out on the lower side, so as to present a larger surface than on the upper side.

2nd. Hexagonal cells formed of adjoining prismatic figures, with rectilinear axes, terminated by a truncated plane, at right angles to the axes of the prisms.

These cells are found in wasps' nests from St. Lucia, in the West Indies, and at Graham's Town, in South Africa, which were placed at my disposal for this investigation by Mr. Robert J. Montgomery.

3rd. Hexagonal cells formed of adjoining prismatic figures, with rectilinear axes, terminated by three faces of a rhombic dodecahedron, which three faces also form each one-third of the termination of a similar set of adjoining hexagonal prismatic cells, placed end to end behind the first set of prisms.

This double comb is produced by the well-known form of the cells of the honey-bee.

All these varieties of cells may be accounted for, simply by the mechanical pressure of the insects against each other during the formation of the cell. In consequence of the instinct that compels them to work with reference to a plane, and of the cylindrical form of the insects' bodies, the cells must be hexagons; and in consequence of the instinct that induces the bees to form double combs, the mutual pressure of their heads against each other compels the bottom of the cell to assume the form of the rhombic dodecahedron. If we could imagine spherical insects endowed with the instinct of working from a point and not a plane, their cells would cease to affect the forms of the hexagon and rhombic dodecahedron, and would imitate the totally different form of the pentagonal dodecahedron—instances of which may be seen in the bubbles produced in the froth of an organic solution, and in the shapes of the elementary cells of vegetables, equally restricted in their growth in every direction—and also in the pentagonal faces assumed by leaden bullets made to fill completely the inside of a hollow shell, and then discharged against a bank of earth, or a wall, from a mortar.

On this subject, I cannot do better than quote the words of Buffon, who was the first person that put forward a rational theory of the shape of the cells of bees. The passage which I quote may be found in his 'Histoire Naturelle,' tom. iv. p. 99:—

"Dirai-je encore un mot; ces cellules des abeilles, ces hexagones, tant vantés, tant admirés, me fournissent une preuve de plus contre l'enthousiasme et l'admiration: cette figure, toute géométrique et toute régulière qu'elle nous paroît, et qu'elle est en effet dans la spéculation, n'est ici qu'un résultat mécanique

et assez imparfait qui se trouve souvent dans la nature, et que l'on remarque même dans ses productions les plus brutes; les cristaux et plusieurs autres pierres, quelques sels, &c., prennent constamment cette figure dans leur formation. Qu'on observe les petites écailles de la peau d'une roussette, on verra qu'elles sont hexagones, parce que chaque écaille croissant en même temps se fait obstacle, et tend à occuper le plus d'espace qu'il est possible dans un espace donné: on voit ces mêmes hexagones dans le second estomac des animaux ruminans, on les trouve dans les graines, dans leurs capsules, dans certaines fleurs, &c. Qu'on remplisse un vaisseau de pois, ou plutôt de quelque autre graine cylindrique, et qu'on le ferme exactement après y avoir versé autant d'eau que les intervalles qui restent entre ces graines peuvent en recevoir; qu'on fasse bouillir cette eau, tous ces cylindres deviendront de colonnes à six pans. On en voit clairement la raison, qui est purement mécanique; chaque graine, dont la figure est cylindrique, tend par son renflement à occuper le plus d'espace possible dans un espace donné, elles deviennent donc toutes nécessairement hexagones par la compression réciproque. Chaque abeille cherche à occuper de même le plus d'espace possible dans un espace donné, il est donc nécessaire aussi puisque le corps des abeilles est cylindrique, que leurs cellules soient hexagones,—par la même raison des obstacles réciproques. On donne plus d'esprit aux mouches dont les ouvrages sont les plus réguliers; les abeilles sont, dit-on, plus ingénieuses que les guêpes, que les frelons, &c., qui savent aussi l'architecture, mais dont les constructions sont plus grossières et plus irrégulières que celles des abeilles: on ne veut pas voir, ou l'on ne se doute pas que cette régularité, plus ou moins grande, dépend uniquement du nombre et de la figure, et nullement de l'intelligence de ces petites bêtes; plus elles sont nombreuses, plus il y a des forces qui agissent également et qui s'opposent de même, plus il y a par conséquent de contrainte mécanique, de régularité forcée, et de perfection apparente dans leurs productions."—*Buffon.*

The opinions of the older writers, especially of mathematicians, on this subject, differ widely from those advanced by Buffon.

I shall here translate some of the most important of the passages bearing on this point.

The famous Pappus, of Alexandria, in the Introduction to the Fifth Book of his Mathematical Collections, says:—

"God has imparted to men, indeed, the best and most perfect knowledge of wisdom and discipline; and has assigned to some animals, devoid of reason, a certain portion. To men, therefore, as making use of reason, He has permitted that they should do all things by reason and demonstration; but to other animals

without reason, He has given the possession of what is useful and conducive to life, by a certain natural providence.

"Any one may understand this to be so, as well in many other kinds of animals, and more especially in bees. For order, and a certain admirable deference to those who rule in their republic, ambition, moreover, and cleanliness, heap together an abundance of honey; but their foresight and economy concerning its conservation are much more admirable: for holding it for certain, as is just, that they carry back some portion of ambrosia from the gods to choice men, they pour out this, not rashly on the ground, or into wood, or any other unformed and misshapen matter; but collecting from the sweetest flowers that grow in the earth, they form from them most excellent vases as a receptacle for the honey (which the Greeks call *κηρία*, and the Latins *favi*), all indeed, equal, similar, and cohering among themselves, of the hexagon species. Now it is thus evident that they construct these by a certain geometrical foresight; for they consider it fit that all the figures should cohere together and have common sides, lest anything, falling into the intervening spaces, should spoil and corrupt their work.

"Hence, three rectilinear and ordinate figures can effect what is proposed—I mean ordinate figures which are equilateral and equiangular, for ordinate and dissimilar figures did not please the bees themselves. Now, equilateral triangles, and squares, and hexagons (neglecting other dissimilar figures filling space) may be placed next each other, so as to have common sides—other ordinate figures cannot; for the space about the same point is filled, either by six equilateral triangles, or by four squares, or by three hexagons; but three pentagons are less than sufficient, and four are more than sufficient to fill the space round a point, neither can three heptagons be established, so as to fill the space round a point*.

"The same reasoning will apply much more to figures having a greater number of sides. There being, then, three figures, which, of themselves, can fill up the space round a point, viz. the triangle, the square, and the hexagon; the bees have wisely selected for their structure that which contains most angles, suspecting, indeed, that it could hold more honey than either of the others.

"The bees, forsooth, know only what is useful to themselves, viz. that the hexagon is greater than the square or triangle, and can hold more honey, an equal quantity of material being employed in the construction of each; but we, who profess to have more wisdom than the bees, will investigate something even

* The proofs of these assertions are omitted in this translation.

more remarkable, viz. that, of plane figures, which are equilateral and equiangular, and have equal perimeters, that is always the greatest which consists of most angles, and the circle is the greatest of all, provided it be included in a perimeter equal to theirs."—*Pappus.*

In 1712, Maraldi published, in the 'Mémoires de l'Académie des Sciences, Paris,' 1712, p. 299, a remarkable paper, in which is investigated, for the first time, the terminal planes of the bees' cell, which are now well known to be formed of the faces of the rhombic dodecahedron. He appears to have believed that the object of having lozenges of the same form, as terminating planes, was to enable the bees to carry in their mind the idea of one geometrical form only, in addition to their original idea of the hexagon. The angles of the lozenge are found by him to be 110° and 70°, by observation; and 109° 28′ and 70° 32′ by calculation. He gives, also, the following mean measurements of the cells:—In a foot long of comb there are from 60 to 66 cells, about two lines for each cell, and the depth of the cell is five lines.

Réaumur appears to have been the first who introduced the fantastic idea of economy of wax, as the motive cause of the peculiar shape of the terminating planes, and, not being a geometer, he obtained the assistance of König to calculate the angle of the lozenge which should give the least surface with a given volume. König determined this angle at 109° 26′, agreeing with Maraldi within two minutes.

MacLaurin published, in the 'Philosophical Transactions,' 1743, p. 565, an elaborate geometrical paper on the subject, in which he proves that the tangent of the angle in question is the square root of 2, and that it is therefore equal to 109° 28′ 16″; and he computes the saving of wax as "almost one-fourth part of the pains and expense of wax they bestow, above what was necessary for completing the parallelogram side of the cells."

L'Hullier, in 1781, published, in the 'Berlin Memoirs,' p. 277, an elaborate discussion of the entire problem, in which he arrived at the following results, already found by MacLaurin's geometrical method:—

a. That the economy of wax is less than one-fifth of what would make a flat base.

b. That the economy of wax, referred to the total expenditure, is $\frac{1}{51}$st, so that the bees can make fifty-one cells, instead of fifty, by the adoption of the rhombic dodecahedron.

He does not share, however, in the enthusiasm of the naturalists, but maintains and proves that mathematicians could make cells, of the same form as those of the bees, which, instead of using only a *minimum* of wax, would use the *minimum mini-*

morum, so that five cells could be made of less wax than that which now makes only four, instead of fifty-one out of fifty.

Notwithstanding this conclusive decision in favour of the mathematicians, the advocates of final cause, and those who maintain that economy of wax can create a new species, have both persisted in using the bees' cell in illustration of their respective theories, with a pertinacity that proves the persistent vitality of an exploded theory. In illustration of this remarkable tendency of false theories to reproduce themselves, I shall here add, as an appendix to my account of the form of the wasps' and bees' cells, some remarks on the origin of species, the substance of which originally appeared in the 'Natural History Review' of 1860.

Appendix on the Origin of Species.

The active and restless mind of man has never been content with the knowledge of the present, but has always sought to know the future and the past. The guesses of the ancients as to the future of man are amongst the most interesting and, at the same time, the most puerile of their philosophical speculations. The reader of the Tusculan Disputations rises from his task, charmed by the style of the writer, but thankful that a certain revelation of the future renders him immeasurably superior in knowledge to the weavers of these pleasant webs of fiction; and though he admires the skill of the ingenious sophists who live again and dispute in the pages of Cicero, he would not for an instant exchange his own position for theirs.

The moderns have resolved, by their speculations on the past, to show that in ingenuity and oddness of conceit, and, probably, also in wideness from the truth, they are in no respect inferior to the ancients. The future being shut out from us, we are resolved to try what we can effect, in proof of our versatility of imagination, by guessing at the history of the past.

To establish a character for subtlety and skill, in drawing large conclusions on this subject from slender premises, the first requisite is ignorance of what other speculators have attempted before us in the same field; and the second is, a firm confidence in our own special theory. Neither of these requisites can be considered wanting in those who are engaged in the task of reproducing Lamarck's theory of organic life, either as altogether new, or with but a tattered and threadbare cloak thrown over its original nakedness.

The sciences of geology and political economy are mainly answerable for the revival of these exploded and forgotten fancies,—geology, in supplying the lost history of organic life, which could never be studied profoundly from the creatures

living at any given time; and political economy, in furnishing, from its mean and sordid motives, a Malthusian force, supposed to be sufficient to supply the wants of previous theories.

One of the earliest speculators on the origin of the diversified forms of life we see around us, and class as varieties, species, and genera, was Buffon, who published in 1766* his theory of the derivation of all mammal forms by degradation, from fifteen primary and perfect types, and nine special or isolated species.

This theory of βιογένεσις by degradation, although now superseded by the theory of progression, has much to be said in its favour, and derives additional importance from the facts of the history of life made known since Buffon's time, by the science of geology. The principal of these additional facts are, the degradation of fishes from their first introduction in the Old Red Sandstone period to the present day; the corresponding degradation of the Cephalopods, and, though in a somewhat less degree, of the Reptiles.

Some of the classes given by Buffon are as old as the time of Moses, who defines with accuracy the class Ruminantia, distinguishing it from the Pachydermata and Rodentia, in his classification of "clean" and "unclean" beasts†.

Whatever may be thought by the more enlightened moderns of the merits of this classification of mammals, Buffon certainly agrees with them in one respect: he takes the non-reality of species as the starting-point of his theory, and by a continued degradation downwards, developes all the varieties of life we see on the surface of the globe.

To those who love to dwell upon the past, this theory of degradation will afford solace and consolation in the troubles of the present, as they can reflect upon how good and excellent their ancestors were, and congratulate each other upon their superiority to those that will come after them. Every system of philosophy provides its followers with a "*solatium doloris*;" the degradationists find it in the contemplation of the past, and the progressionists in the prospect of the future; to those who are contented with the present, and deny our knowledge of the past or future, both theories appear as the idle dreams of childhood, the awakening from which will disclose a reality totally different from the troubled fancies of the night.

Lamarck is the father of the progressionists; and of the many who quote his name as an authority in support of their systems, or express their disapproval of his doctrine, few have taken the trouble to understand his theory or trace it to its origin. It is apparently founded on the confusion of species, like that of Buffon; but there is in reality an *arrière-pensée*, like an unseen

* Histoire Naturelle, tom. xiv. † Leviticus, xi. 2–8.

presence, which corrupts his reasoning, and discloses the motive force of his entire system. This hidden spring of action and theorizing is a profound and, as many think, a well-founded contempt for humanity, which pervades his writings as thoroughly as it does the "Voyage to the Houyhnhnms." Lamarck was too quick-witted and acute an observer, however deficient he may have been as a reasoner, to have believed his own theory, the real mainspring of which is the desire to degrade man into an intelligent baboon or Yahoo; what difference is there in a name! In his desire to do so, he overlooks every fact at variance with his foregone conclusion, and writes of mankind with a virulence which, though devoid of the wit of Swift, springs from the same profound and unalterable conviction of the worthlessness of the creature he describes:—

"Si Newton, Bacon, Montesquieu, Voltaire, et tant d'autres hommes ont honoré l'espèce humaine par l'étendue de leur intelligence et de leur génie, combien ne la rapprochent pas de l'animal cette quantité d'hommes bruts, ignorans, en proie aux préjugés les plus absurdes, et constamment asservis par leurs habitudes, qui cependant composent la masse principale chez toutes les nations?"*

Lamarck's contempt for his species is again shown in the strange list of resemblances he selects for his comparison between man and the chimpanzee—a comparison fully as degrading as Swift's mock imitation of a naturalist's description of a Yahoo.

Lamarck's theory consists in the assertion of the following laws, six in number, which he dignifies with the title of Laws of Nature:—

I. *Law of Specialization of Function,* by which a function at first general, or belonging to the whole body, is determined to a particular organ.

II. *Law of Nutrition producing Death* by the forced inequality between the materials fixed by assimilation and removed by exeretion. This law is intended to account for death, which is a puzzle to the naturalists.

III. *Law of Movement of Complex Fluids in Canals.* This law I profess my inability to understand. In the statement of it, Lamarck, who, like most naturalists, is unacquainted with physics, and untrained in the severe discipline of mathematical reasoning, attributes properties to fluids in motion which must be considered by lookers-on as little short of miraculous.

IV. *Law of Change of Composition of Fluids in Circulation.* This law is as obscure, and as miraculous in its results, as the

* Recherches sur l'Organisation des Corps Vivans, p. 127. Paris, 27 Floréal, An X.

preceding. Natural religion, however, would appear to consider herself entitled to her miracles, as well as revealed religion.

V. *Organic Forms, acquired under the presiding influence of external circumstances, are transmitted by Generation.* This law involves the famous Law of Natural Selection, attributed within the last few months to Mr. Darwin.

VI. *By the concurrence of the preceding Laws, of a long lapse of time, and an almost inconceivable diversity of surrounding circumstances, all Species have been formed in succession.* Lamarck's theory is essentially one of progression, and is totally opposed to that of Buffon, which is one of degradation; yet it is remarkable that they both rest upon the same foundation—the assumed non-reality of species. Like his successors in the Progression theory, Lamarck spent his life in the establishment of the reality of species; and it is a humiliating reflection, that, at the close of it, he believed himself to have lived under a delusion. Let us hear his confession:—

"J'ai long-temps pensé qu'il y avait des *Espèces* constantes dans la nature, et qu'elles étoient constituées par les individus qui appartiennent à chacune d'elles. Maintenant je suis convaincu que j'étois dans l'erreur à cet égard, et qu'il n'y a réellement dans la nature que des individus."

What must we think of the principles that guide the speculations of naturalists, when we find minds like those of Buffon and Lamarck drawing opposite conclusions from the same premises? It matters little in this question whether the premises be true or false, whether species be truly distinct or not; our surprise at the logic of the naturalists is natural, and must border on a courteous contempt.

The English revival of Lamarckianism, or "Progress in Organic Life," by Mr. Darwin, involves no idea in advance of those contained in Lamarck's six laws, but gives a greater prominence to the law of Continuation of Peculiarities by Generation, by the assertion that such peculiarities, and such only, as are useful to the creature, in its struggle for existence, will become hereditary—the reason being, that animals provided with such peculiarities will have the advantage in the battle of life over their fellows in the competition for food, females, and other necessaries for the preservation of the individual and species. This notable argument is borrowed from Malthus's doctrine of population, and will, no doubt, find acceptance with those political economists and pseudo-philosophers who reduce all the laws of action and human thought habitually to the lowest and most sordid motives. It is dignified with the title of a Law of Nature, called the *Law of Natural Selection*, and forms the only *bonâ fide* addition made by Darwin to Lamarck's famous

theory of Progression, in which, however, it is implicitly involved.

I make no account of Mr. Darwin's geological additions to Lamarck, for two reasons. In the first place, the laws of geographical distribution explained by geological change are not *ad rem*, and were previously fully treated of by Buffon and Forbes; and in the second place, Mr. Darwin admits that the facts of geology are opposed to his (Lamarck's) theory; and they are pleasantly alluded to as the geological difficulty! So far as the history of life on the globe indicates a progression, Lamarck is entitled to the benefit of it—as in the case of mammals and plants,—but certainly not to the exclusion of the facts in favour of degradation—such as the case of Fishes, Reptiles, and Cephalopods, which must be credited to the account of Buffon and his followers.

Lamarck says distinctly—"Ce ne sont pas les organes, c'est-à-dire, la nature et la forme des parties du corps d'un animal, qui ont donné lieu à ses habitudes et à ses facultés particulières; mais ce sont au contraire ses habitudes, sa manière de vivre, et *les circonstances dans lesquelles se sont rencontrés les individus dont il provient*, qui ont *avec le temps* constitué la forme de son corps, le nombre et l'état de ses organes, enfin les facultés dont il jouit."

This statement implies all that is essential in Mr. Darwin's "law of Natural Selection," which, by its prominence, fills in his system the place occupied by the law of Imitation in the original theory of Lamarck. This difference arises from the difference of the points of view of the Frenchman and the Englishman—a difference characteristic of the two races. The Frenchman, with the vivacity and perception of the ridiculous belonging to his nation, seizes upon the quality most likely to elevate a monkey into a man, selects the faculty of imitation, and, with a bitter satire, endows his monkey with the human desire to better his condition, and lift himself above his brother chatterers. He thus magnifies the monkey power of imitation—which is truly wonderful, and extends to the most extraordinary actions—into the position of a law of nature, sufficient to create man! The Englishman, on the other hand, firmly believes his theory, and, with a confident faith in the power of food and comfort, equally characteristic of his country, elevates the desire to supply the stomach into a law of sufficient force to convert an eel into an elephant, or an oyster into an orang-outan.

Other theorists, whose name is legion, have printed their crude fancies, and have met with numerous readers among the young and inexperienced, the sciolists of science. It is not to

be supposed that a public which accepted mesmerism and table-turning could judge with accuracy of the pretensions of loose and ill-reasoned speculations on the origin of life. It has rained, hailed, and poured theories of life—religious, philosophical, and pseudoscientific—with a marvellous rapidity within the last few years. Some theorists have started from the nebular hypothesis of Laplace; others have speculated on the results of superfœtation; and others on the brilliant and seductive theory of the correlation of physical forces; but they may all be classed as, knowingly or not, the followers of Lamarck. Some have taught that all the planets, being composed of the same mineral constituents as the earth, must produce in succession the same organic phenomena, and weary the reader with the idea of the same Pterodactyles and Cetacea, the same monads and men, appearing on all the globes that circle round the sun! Others have called to mind the loss of heat of our planet, and, by the correlation of forces, have reproduced it in the increasing intelligence of the successive forms of life that have peopled our globe!! In a word, there is no folly that human fancy can devise, when truth has ceased to be of primary importance, and right reason and sound logic have been discarded, that has not been produced and preached as a new revelation. Neither have the disciples of Lamarck wanted the martyr spirit, *i. e.* the disposition to make martyrs of others, which is generally supposed to be essential to the apostles of a new faith. They have courted persecution, and reviled their opponents with bitter words, and with such weapons as are permitted by the free civilization under which we live. They argue, with a logic worthy of their system, that because truth has been often in a minority, therefore minorities and theories in a minority must necessarily be true.

It is curious to observe the natural instinct by which Lamarck and his followers appeal from the judgment of their peers to the young, the enthusiastic, and the inexperienced. I shall quote but two instances of this necessary instinct of self-preservation:—

"Que de réflexions ces considérations pourront faire naître dans l'esprit du petit nombre de ceux qui en sont susceptibles et qui sont lents à prononcer! les autres auront bientôt fait à cet égard: ils trancheront sans examen, et décideront d'après ce qui leur conviendra le mieux, ou selon la portée de leurs conceptions."—*Lamarck*, p. 123.

"I by no means expect to convince experienced naturalists, whose minds are stocked with a multitude of facts, all viewed, during a long course of years, from a point of view directly opposite to mine . . . . . ; but I look with confidence to the future, to young and rising naturalists, who will be able to view

both sides of the question with impartiality."—*Darwin's Origin of Species*, pp. 481–82.

The theories of βιογένεσις, already described, and many others, are based upon the following three unwarrantable assumptions, the denial of which, until proved, brings to the ground the entire structure, like a child's house of cards—

I. *The indefinite variation of species continuously in the one direction.*

II. *That the causes of variation assigned*, viz. cross-breeding (Buffon), imitation (Lamarck), and natural advantage in the struggle for existence (Darwin), *are sufficient to account for the effects asserted to be produced.*

III. *That succession implies causation.*

On each of these a few words of explanation are necessary.

I. *The indefinite variation of species continuously in the one direction.*

This has been expressed by some Lamarckians as a state of unstable equilibrium of nature; but should we assume the existence of a law which is contrary to all we know of every other department of nature? If we must have a mechanical analogy to fix our ideas, nature might be better compared to a condition of *dynamic equilibrium*, in which all the parts are in motion, and never return to precisely the same relative positions, but, nevertheless, continually balance round certain definite positions of equilibrium, which never change. What should we think of the astronomer who, from a few years' observation of the precession of the equinoxes, should predict that in due time the north pole of the earth's axis would point to the same position among the stars that the south pole now occupies? yet this very species of assumption is made by Lamarck and Darwin, in their appeal to the supposed influence of a long lapse of time. Yet, in the writings of the latter progressionist there is this singular inconsistency, that while he shows the utmost effects of human breeding on domestic animals to be capable of production in ten or twenty years, he denies the right of his adversaries to appeal to the unaltered condition of the ass, the ostrich, or the cat for 3000 years as a proof that specific forms balance round central types, and have no tendency to depart indefinitely from them.

Is it rational to suppose that man can alter the head and neck of a pigeon into any desired form in six years, and that nature, with her greater skill, cannot in 3000 years lengthen the ostrich's wings by a single inch, although, according to the theory, it is her evident wish to do so?

II. *The causes of variation assigned are not adequate to produce the effects assigned to them.*—The discussion of the inade-

quacy of the causes assigned would lead to a treatise longer than that of Buffon, Lamarck, or Darwin; and I must therefore content myself with an example. The humble bee and the hive-bee coexist together, and the latter is supposed to be developed from the former by the law of natural selection, breeding, in succession, bees possessed of the talent of economizing more and more of wax in the construction of their cells.

1. The humble bee constructs single cells and uses 100 units of wax.

2. A bee (not known to science, but, doubtless, extinct) was grown, that made cells in the form of *equilateral triangles* placed in double combs, with flat bottoms to the cells. This bee used only 50 units of wax.

3. A bee (also extinct) was grown, that built *square* cells in double combs. This bee used only $41\frac{2}{3}$ units of wax.

4. A bee (also extinct) was grown, forming *hexagonal* cells with flat bottoms, in double combs. This bee used $33\frac{1}{3}$ units of wax.

5. The hive-bee (now living side by side with his humble progenitor) was produced by natural selection dependent on the economy of wax, arising from the contrivance of substituting for the flat bottoms of the hexagonal cells the trihedral angles and planes of the rhombic dodecahedron.

This bee (*our* bee) uses $32\frac{2}{3}$ units of wax.

6. The *Bee of the Future* (not yet produced), which shall have learned how to construct the cell described by the mathematician L'Hullier.

This bee will be broader and shorter than the present, the breadth and length admitting of prediction to any degree of approximation.

This Bee of the Future will only require $24\frac{1}{2}$ units of wax!! *Vivat Geometria*!

Of these six species of bee (the first and the fifth are living), No. 5 using only $32\frac{2}{3}$ lbs. of wax in the construction of its cells for every 100 lbs. used by No. 1. According to the Malthusian law, No. 5 has exterminated No. 4, by virtue of the trifling advantage of $\frac{2}{3}$rds of a pound of wax in every 100 lbs.; and this slight advantage is gravely alleged as the efficient cause of converting one species of bee into another! This would be all very well, if No. 1, the spendthrift humble bee, were not still living, and holding his ground well against his enemies, to bear witness against this silly theory.

In fact, the whole question of the economy of wax, and other such questions, require a thorough sifting. To my mind, it is evident that economy of wax has nothing whatever to do with the making of the bee's cells, but that this and other properties,

such as maximum resistance to fluid pressure, &c., necessarily reside in the bee's cell because they are the inherent properties of the rhombic dodecahedron, which is the form affected by that cell. The true cause of that shape is the crowding together of the bees at work, jostling and elbowing each other, as was first shown by Buffon. From this crowding together, they cannot help making cells with the dihedral angles of 120° of the rhombic dodecahedron; and the economy of wax has nothing to do with the origin of the cell, but is a geometrical property of the figure named.

III. The most serious logical blunder committed by all who invent a theory of life from the geological succession is, that *Succession implies causation.* It is agreed that the Palæozoic Cephalopoda produced, in some way or other, the Red Sandstone fishes; that these in turn gave birth to the Liassic reptiles; that the non-placental mammals of the Upper Oolite *grew* after some fashion, and ultimately produced the Tertiary mammals, some of which, in an unhappy hour, gave birth to man. The only fact at the basis of this astonishing inverted cone of reasoning is, that these creatures *did* succeed each other in the manner described; and from this, forsooth, it follows (*post hoc, ergo propter hoc*) that they succeeded each other in the way of cause and effect. I propose to test this strange theory by a corresponding theory of the mineralogical succession of igneous rocks, which opens up a fertile field of speculation, hitherto unwrought. The igneous rocks of the Palæozoic period contain abundance of felspar, whose principal constituent is potash; the Mesozoic igneous rocks abound in soda, replacing potash; and in the Tertiary period, soda itself gives way to lime and magnesia. Viewed in the light of the Lamarckian philosophy, here is a distinct indication that soda and lime are only allotropic conditions of potash. We may read the history of their formation in the crust of the globe, if we will only open our eyes and see it written. I may add, by the way, that this theory of the origin of lime is more intelligible than that of many geologists, who would attribute the greater accumulations of calcareous rocks in secondary and tertiary strata to the creation of lime by organic force.

If any chemist or mineralogist were to put forward such a geological theory of the origin of soda and lime as the foregoing, he would be regarded as a lunatic by other chemists and mineralogists.

How does it happen that a theory of the origin of species, which rests on the same basis, is accepted by multitudes [?] of naturalists as if it were a new gospel? I believe it is because our naturalists, as a class, are untrained in the use of the logical

faculties which they may be charitably supposed to possess in common with other men. No progress in natural science is possible as long as men will take their rude guesses at truth for facts, and substitute the fancies of their imagination for the sober rules of reasoning.

It has been well observed by the greatest of living palæontologists, "that past experience of the chance aims of human fancy, unchecked and unguided by observed facts, shows how widely they have ever glanced away from the golden centre of truth!"

XLVI.—*On the former Connexion of North Africa with South Europe.* By Prof. Edward Suess*.

A letter lately received from M. Anca, of Palermo, addressed to M. Senoner, induces me to return to a subject which I have previously discussed, but the repeated consideration of which appears to me adapted to show the value which is possessed by the researches of M. Anca and some similar observations, even in connexion with the investigations now being carried out at Vienna.

On the former occasion, I mentioned, as having resulted from the investigations of our distinguished Professor Hörnes regarding the fossil Mollusca of the Vienna Basin, an unexpected identity of some species of our marine strata with shells now living on the coast of Senegambia.

I then named as examples *Cypræa sanguinolenta*, *Buccinum lyratum*, and *Oliva flammulata*, and inferred, in accordance with the descriptions we possess of the great Sahara, that a sea once extended from the Gulf of Gabes to the region south of the Idjil range in the province of Aderer uniting the Senegambian shores with those of the Mediterranean. I appealed to the detailed statements of Laurent, who was commissioned to execute Artesian borings on the north border of the desert. In his report, he represented the desert as once covered by a wide arm of the sea which flowed in from the Gulf of Gabes, and of which unmistakeable traces are to be seen in the repeated terraces along the south border of the Aoures Mountains, where the former positions of the sea-coasts are indicated also by one of the most abundant inhabitants of the Mediterranean coast, *Cardium edule*, the shells of which lie here strewn about in great quantities, and which is even said to be still living in some pools of the desert. I also added that, at present, considerable tracts of the

* From the Transactions of the Royal Imperial Geological Institution of Vienna, January 1863. Communicated by Mr. S. P. Woodward.